JOURNAL OF THE
WORLD AQUACULTURE SOCIETY

Vol. 37, No. 4
December, 2006

Effect of Photoperiod on Feeding, Intraperitoneal Fat, and Insulin-like Growth Factor-I in Sunshine Bass*

KENNETH B. DAVIS[1,2] AND MATTHEW MCENTIRE

USDA/ARS Harry K. Dupree Stuttgart National Aquaculture Research Center, P.O. Box 1050, Stuttgart, AR 72160, USA

Abstract

The length of the photoperiod has been implicated as affecting growth of sunshine bass. This study was done to determine if photoperiod length might affect insulin-like growth factor-I (IGF-I), which is a major hormonal regulator of growth in fish. Growth, feed conversion, peritoneal fat content, and plasma concentrations of IGF-I of sunshine bass were compared on fish held on a short (8 h) or a long (16 h) photoperiod, or after the fish were switched from one photoperiod to the other. Fish were fed daily to apparent satiation for up to 5 wk and were not fed for the last 2 wk of the experiment. Body weight and intraperitoneal fat content increased for the first 2 wk of the experiment and then remained steady for the remainder of the experiment, and feed consumption decreased from 3.5% during the first 2 wk to about 1.5% for the second 2 wk and finally to only 1% during the last week of feeding. Plasma IGF-I concentrations fell steadily during the entire experiment and was at the lowest level during the last 2 wk when the fish were not fed. There was no consistent effect of the photoperiod in any of the conditions; however, feeding and IGF-I concentrations were affected by fish density.

Environmental conditions required for the successful culture of hybrid striped bass are fairly well understood (Tomasso 1997), as are the lethal concentrations of toxic by-products of fish metabolism such as ammonia (Openborn and Goudie 1993; Weirich et al. 1993). The impact of environmental conditions on physiological growth regulators is less well understood. If physiological measurements reflect the growth of fish, evaluation of culture condition could be accomplished much quicker and cheaper than lengthy growth studies. In outdoor culture situations, management for optimum conditions is limited by the changing of the seasons and cost constraints. In recirculating or flow-through culture, environmental conditions, such as temperature and photoperiod, can be more easily regulated. Palmetto bass (striped bass female × white bass male) had higher survival in shaded aquariums and ponds than in nonshaded aquariums and ponds (Rees and Cook 1985). Palmetto bass have also been shown to grow faster during increasing rather than decreasing photoperiods in fiberglass tanks (Woiwode and Adelman 1991) and in ponds (Kerby 1993). The length of the photoperiod can easily be manipulated in intensive culture and might be an important environmental condition that could be easily manipulated with little additional cost to producers.

Fish growth is most directly affected by feed nutrients and the amount of feed consumed. The major endocrine axis controlling growth is regulated by the pituitary/liver/somatic axis. Growth hormone from the pituitary stimulates the liver to synthesize and release insulin-like growth factors (IGF-I and IGF-II) from the liver. IGF-I is a powerful mitogenic factor that helps maintain cell number by reducing apoptosis and is considered the most important hormonal growth regulator in mammals (Lupu et al. 2001). Extensive reviews of this axis in fish have been published (Duan et al. 1999; Moriyama et al. 2000; Kelley et al. 2001). Plasma IGF-I concentrations have been correlated with

[1] Corresponding author.

[2] Present address: Catfish Genetics Research Unit, United States Department of Agriculture, Agricultural Research Service, 141 Experiment Station Road, Stoneville, MS 38732, USA.

* Mention of a trade name, proprietary product, or specific equipment in the article is solely for the purpose of providing information and does not imply recommendation or endorsement by the US Department of Agriculture.

growth rate in aquacultured fish, and plasma IGF-I has been suggested as a tool for assessing the growth potential of new diets (Dyer et al. 2003). Plasma IGF-I increases with temperature in sunshine bass (Davis, unpublished data) and may be useful in identifying culture conditions that promote growth.

This study was undertaken to determine the effect the length of the photoperiod has on feed intake, growth, intraperitoneal fat (IPF) storage, and plasma IGF-I concentrations.

Materials and Methods

Sunshine bass is a hybrid produced by crossing a female white bass, *Morone chrysops*, with a male striped bass, *Morone saxatilis*. Thirty sunshine bass about 2 yr old and weighing 132.7 ± 19.4 g (mean ± SD) were randomly stocked into each of four round 700-L tanks. Two tanks were held on a l6 h light : 8 h dark (long) and two on an 8 h light : 16 h dark (short) photoperiod and supplied with single-use flow-through well water at 23 C. The light intensity at the water level averaged 7.06 lx. Fish were fed with a 45% protein floating commercial feed (Silver Cup, Murray, UT, USA) to satiation once a day at the beginning of the photoperiod. Satiation was determined by feeding the fish by hand until 1 min passed during which no feeding occurred with feed present in the tank. The amount of feed eaten each day was weighed and expressed as the percent of the body weight per day eaten based on the last weighing. The study ran for 7 wk beginning on April 2 and concluded on May 21. Fish were fed for the first 5 wk, and each fish was weighed weekly starting with Week 2. At the end of the third week, one long-photoperiod tank was exposed to a short photoperiod and one short-photoperiod tank was exposed to a long photoperiod. At the end of the fifth week of feeding, the fish were fasted for the next 2 wk and weighed at the end of each week.

Sample collection started the second week; six unanesthetized fish from each treatment were bled, the blood centrifuged, and the plasma frozen for later analysis. The IPF was determined and expressed as the percent of the body weight (Gaylord and Gatlin 2000). Plasma IGF-I concentrations were determined by radioimmunoassay (GroPep Inc., Adelaide, Australia) previously validated for sunshine bass (Davis and Peterson 2005).

The experimental unit for all the statistical tests was the individual fish. The means of a parameter by week were compared among the various treatments by ANOVA. Significant subgroups ($P < 0.05$) were identified by Tukey's multiple range test when a significant AOV was indicated.

Results and Discussion

During the first 3 wk of the experiment, the fish grew rapidly from about 140 g to about 250 g. Fish growth in all experimental conditions slowed markedly, and average fish weight remained about 250 g for the rest of the experiment. There were no differences among the treatment groups at any time during the experiment that was due to the photoperiod (Fig. 1). An interaction of temperature and photoperiod has been reported to have significant effects on growth of hybrid striped bass, and faster growth occurred at higher temperatures and increasing photoperiods (Woiwode and Adelman 1991).

Feed consumption was about 3.5% of the body weight per day for first 2 wk of the experiment and then dropped to 2% the third week and continued to fall until feed consumption was only about 1% the fifth week of the experiment when feeding was halted (Fig. 2). The number of fish decreased each week because six fish were removed from each treatment to estimate body composition, and the feeding intensity decreased when the density of the fish decreased. Photoperiod alone does not appear to have an effect on growth or feed consumption. In spite of the fish not receiving any food during the last 2 wk of the experiment, average fish weight was not dramatically affected although the number of fish was much smaller by the end of the experiment.

IPF also increased during the first 3 wk of the experiment and then remained at around 6% of the body weight throughout the remainder of the experiment. IPF was apparently not mobilized during the 2 wk of no feeding (Fig. 3).

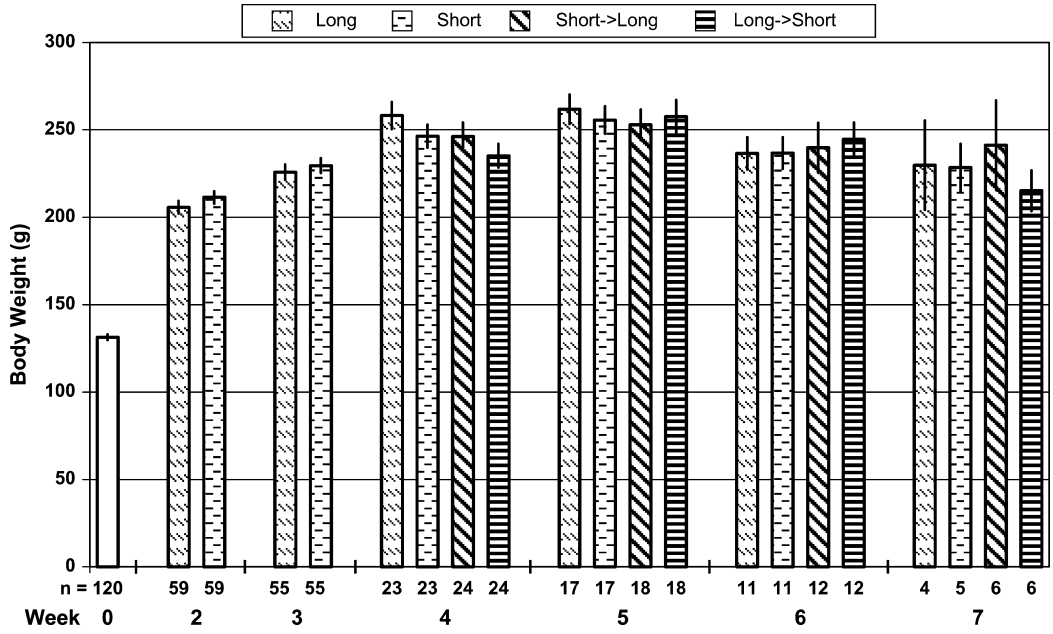

FIGURE 1. *Body weight of fish held under a 16-h (long), 8-h (short), changed from a long to a short (long > short), or changed from a short to a long (short > long) photoperiod after 3 wk. Fish were fed to satiation once a day for 5 wk. Fish were not fed during the last 2 wk. The number of fish in each sample treatment is shown beneath each bar.*

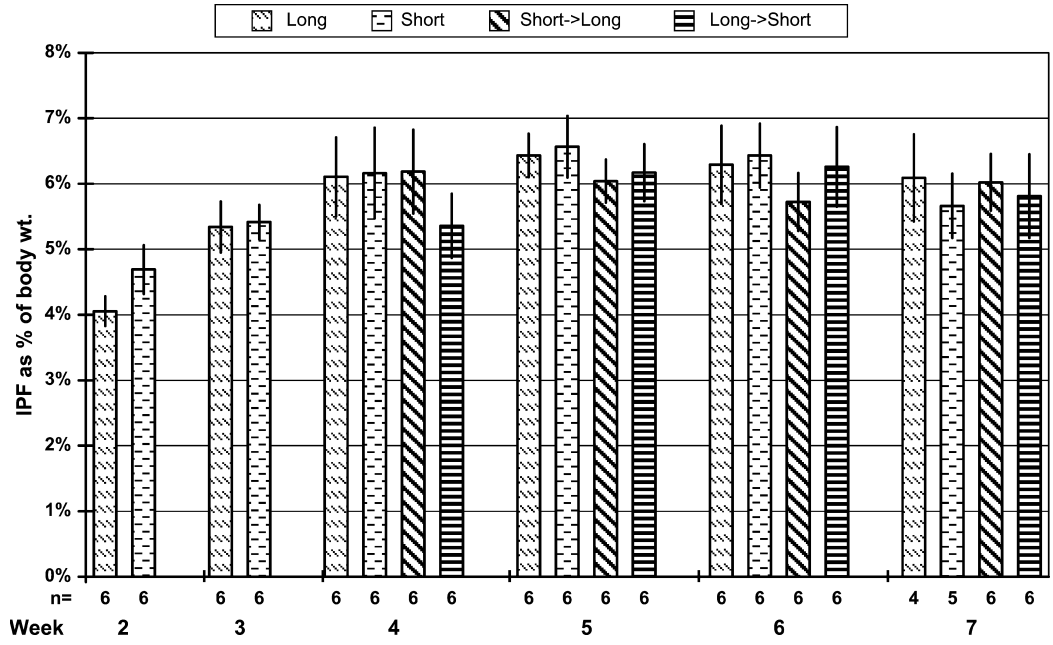

FIGURE 2. *Intraperitoneal fat (IPF) from fish held under conditions described in Figure 1.*

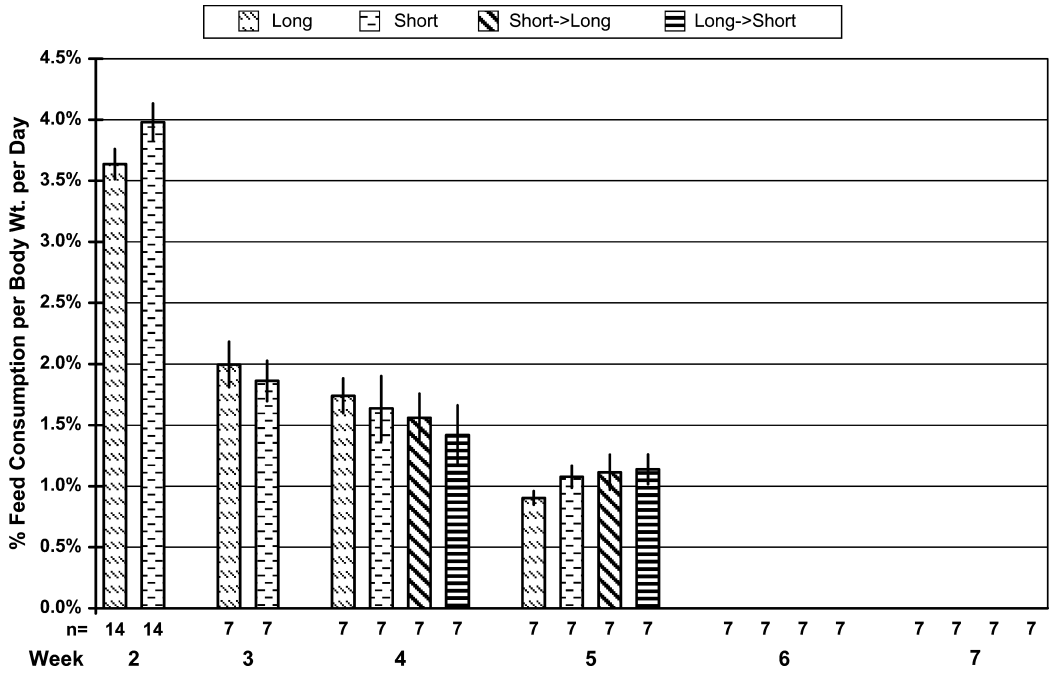

FIGURE 3. *Feed consumption expressed as percent of the body weight per day for fish held under condition described in Figure 1.*

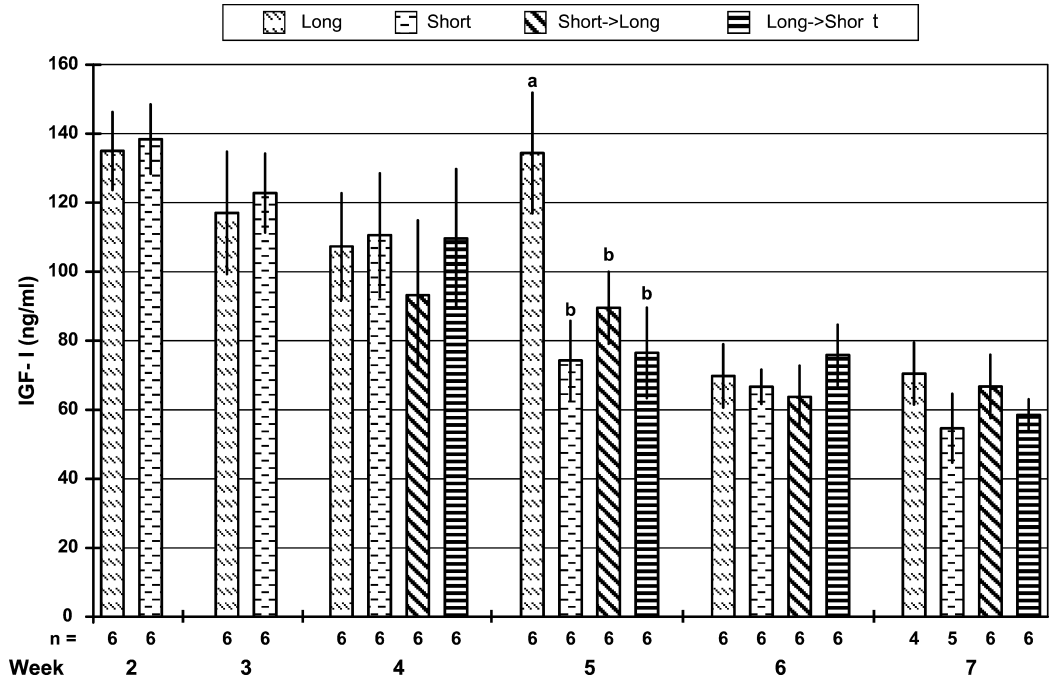

FIGURE 4. *Plasma insulin-like growth factor I (IGF-I) concentrations in fish held under condition described in Figure 1. Letters above each bar represent significantly different subsets by Tukey's multiple range test at* $P < 0.05$.

Energy reserves from some other tissues, such as the liver, must have supplied enough energy to support the fish. There was no effect due to the photoperiod.

IGF-I generally decreased during the experiment, but there was no consistent effect of photoperiod on IGF-I during the experiment (Fig. 4). Fish on a long photoperiod after 5 wk had a significantly higher IGF-I concentration than any of the other groups, but the lack of a consistent IGF-I pattern leads us to consider this one difference an anomaly. IGF-I concentrations during the last 2 wk of the experiment were lower, but not dramatically so, than the previous week when the fish were fed. There were no consistent differences in IGF-I concentrations among any of the photoperiod treatments.

Light intensity affects fish; however, it was thought that the effect of direct sunlight did not afford the fish an opportunity to find cover because partial shading improved survival (Rees and Cook 1985). Most of the studies of effects of photoperiod and temperature have shown a strong interaction between the two environmental stimuli. A changing photoperiod influenced the growth rate and optimum temperature for growth in palmetto bass (Woiwode and Adelman 1991). A possible advantage of a long photoperiod might be observed if the fish were fed more than one time of day. A long photoperiod would allow a longer time between feedings and result in more food taken by the fish. The lowering of the density of the fish in the tank each week might also have changed the feeding intensity by decreasing feeding aggressiveness. Decreased feeding aggressiveness when hybrid striped bass fish were held at low densities has been observed by Steve Rawles (personal communication), and a similar relationship has been described for other species (Kaiser et al. 1995, as cited in Kestemont and Baras 2001). The present data suggest that photoperiod alone has no significant effect on feed consumption, growth, or plasma IGF-I concentrations in sunshine bass held at 23 C.

Acknowledgments

The gift of the sunshine bass by Keo Fish Farm, Keo, Arkansas, is gratefully acknowledged. The authors thank Wayne Moring and Robert Ideker for technical support. Drs. Bill A. Simco, Gerald Ludwig, and Andrew Mitchell made valuable comments on the manuscript.

Literature Cited

Davis, K. B. and B. C. Peterson. 2005. Comparison of insulin-like growth factor-I and insulin-like growth factor binding protein concentrations of the palmetto and sunshine bass and the effects of gender and stress. Journal of the World Aquaculture Society 36:384–392.

Duan, C., J. Ding, L. Qin, W. Tsai, and K. Pozios. 1999. Insulin-like growth factor binding protein 2 is a growth inhibitory protein conserved in zebrafish. Proceedings of the National Academy of Science of the United States of America 96:15274–15279.

Dyer, A. R., C. G. Barlow, M. P. Bransden, C. G. Carter, B. D. Glencross, N. Richardson, P. M. Thomas, K. C. Williams, and J. F. Carragher. 2003. Correlation of plasma IGF-I concentrations and growth rate in aquacultured finfish; a tool for assessing the potential of new diets. Aquaculture 362:583–592.

Gaylord, T. G. and D. M. Gatlin III. 2000. Assessment of compensatory growth in channel catfish Ictalurus punctatus R. and associated changes in body condition indices. Journal of the World Aquaculture Society 31:326–336.

Kaiser, H., O. Weyl, and T. Hecht. 1995. The effect of stocking density on growth, survival and agonistic behaviour of African catfish. Aquaculture International 3:217–225.

Kelley, K. M., J. T. Haigwood, M. Perez, and M. M. Galima. 2001. Serum insulin-like growth factor binding proteins (IGFBPs) as markers for anabolic/catabolic condition in fishes. Comparative Biochemistry and Physiology Part B 129:229–236.

Kerby, J. H. 1993. The striped bass and its hybrids. Pages 251–306 *in* R. R. Stickney, editor. Culture of nonsalmonid freshwater fishes, 2nd edition. CRC Press, Boca Raton, Florida, USA.

Kestemont, P. and E. Baras. 2001. Environmental factors and feed intake: mechanisms and interactions. Pages 141–142 *in* D. Houlihan, T. Boujard, and M. Jobling. editors. Food intake in fish. Blackwell Science, Ames, Iowa, USA.

Lupu, F., J. D. Terwilliger, K. Lee, G. V. Segre, and A. Efstratiadis. 2001. Roles of growth hormone and insulin-like growth factor 1 in mouse postnatal growth. Developmental Biology 229:141–162.

Moriyama, S., F. G. Ayson, and H. Kawauchi. 2000. Growth regulation by insulin-like growth factor-I in fish. Bioscience, Biotechnology and Biochemistry 64: 1553–1562.

Openborn, J. B. and C. A. Goudie. 1993. Acute and sublethal effects of ammonia of striped bass and hybrid striped bass. Journal of the World Aquaculture Society 24:90–101.

Rees, R. A. and S. F. Cook. 1985. Effect of sunlight intensity on survival of striped bass × white bass fry. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 36:83–94.

Tomasso, J. R. 1997. Environmental requirements and noninfectious diseases. Pages 253–270 *in* R. M. Harrell, editor. Striped bass and other Morone culture. Elsevier, Amsterdam, the Netherlands.

Weirich, C. R., J. R Tomasso, and T. I. J. Smith. 1993. Toxicity of ammonia and nitrite to sunshine bass in selected environments. Journal of Aquatic Animal Health 5:64–72.

Woiwode, J. G. and I. R. Adelman. 1991. Effects of temperature, photoperiod and ration size on growth of hybrid striped bass × white bass. Transactions of the American Fisheries Society 120:217–229.